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NON-DESTRUCTIVE ASSAY AND NON-DESTRUCTIVE EXAMINATION OF LOW LEVEL WASTE - PROGRAM DEVELOPMENT

Report No. 90-319-K

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ABSTRACT

Disposal of Ontario Hydro's low level waste will require support in two areas: non-destructive assay so that the waste being emplaced conforms to the radioactivity limit of the disposal facility and non-destructive examination to ensure the physical integrity of the waste being emplaced. An attempt was made to develop a comprehensive research program addressing issues related to these areas for all types of waste presently being generated and with due consideration to expected developments in waste management in the future. To develop assaying capability, techniques for in-situ gamma spectrometry of routine waste streams are needed along with correlations between gamma emitters and alpha/beta emitters present in those wastes. In the area of non-destructive examination, techniques to detect liquid within waste packages need to be explored; to outline and prioritize a broader program in this area, an assessment of the state of the stored waste would first be required.

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EXECUTIVE SUMMARY

NON-DESTRUCTIVE ASSAY AND NON-DESTRUCTIVE EXAMINATION OF LOW LEVEL WASTE - PROGRAM DEVELOPMENT

A. Husain

Ontario Hydro generates annually about 2000 m^3 of solid radioactive waste and about 200 m^3 of liquid radioactive waste; the latter could increase significantly due to planned solvent cleaning of steam generators. Wastes are stored in a variety of storage structures at BNPDS with the liquid waste requiring to be solidified prior to storage.

The stored waste will eventually have to be disposed of in a low level waste repository. With no approved disposal concept and a long drawn-out process of concept evaluation, site selection and repository construction, a disposal facility for the radioactive waste would, however, not be available for at least another 15 to 20 years.

Degradation of stored waste under an extended storage environment is of great concern. The waste at the end of its storage duration must retain sufficient integrity to permit its final emplacement in a repository. An assurance that waste forms/packages can survive the rigours of handling and transportation to the disposal facility would be crucial to avoid widespread dispersion of contamination arising from their unanticipated failure. In addition to ensuring the physical integrity of waste forms/packages, acceptance criteria of the disposal facility will also place a limit on their level of radioactivity. Hence, there is a need for a quality assurance (QA) and a quality control (QC) program in support of our future low level waste disposal. The extent to which such a program is in place and operating will determine the need for any future reconditioning and repackaging of waste prior to disposal.

This report attempts to develop a comprehensive research program addressing issues related to QA/QC of our low and intermediate level waste. Specifically, non-destructive assay (NDA) to determine the radioisotope inventory of a waste

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form/package and non-destructive examination (NDE) to determine its integrity, presence of free liquid, extent of container corrosion, etc. are addressed. Existing capabilities are assessed and areas requiring research are identified. Priorities are assessed in the light of current and future waste management practices.

The following NDA related work is accordingly required:

1. Develop correlations between the activities of gamma, beta and alpha emitters - while the work involves destructive sample analysis, the correlations would enable the activity of beta and alpha emitters within waste packages to be quantified based on in-situ measurement of their gamma activity, and

2. Investigate techniques for in-situ gamma spectrometry

The work should focus on the major routine waste streams, namely, compactible, incinerable and non-processable waste (including IX resins) and consider waste packages arising from both current and future processing methods including immobilization where appropriate. With respect to Item 2 above, a comprehensive literature review and assessment of available technologies (a number of new drum assay systems have recently been described and are also commercially available) should be a logical first step.

Unlike the availability of waste radionuclide characterization data, not enough is known about the state of the stored waste to allow a clear indication of NDE research priorities. An exception to this is the known presence of liquids within some types of wastes. A related concern would be the presence of liquids arising from improper immobilization of liquid wastes. Hence, methods to detect the presence of liquid within waste packages must be developed. In general, an assessment of the state of stored waste must be carried out before NDE research priorities can realistically be assigned.

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To: D. Mills
Director of Research

NON-DESTRUCTIVE ASSAY AND NON-DESTRUCTIVE EXAMINATION OF LOW LEVEL WASTE - PROGRAM DEVELOPMENT

1.0 INTRODUCTION AND BACKGROUND

Ontario Hydro generates annually about 2000 m^3 of solid radioactive waste and about 200 m^3 of liquid radioactive waste/1/; the latter could increase significantly due to planned solvent cleaning of steam generators. Waste are stored in a variety of storage structures at BNPDS with the liquid waste requiring to be solidified prior to storage.

The stored waste will eventually have to be disposed of in a low level waste repository. With no approved disposal concept and a long drawn-out process of concept evaluation, site selection and repository construction, a disposal facility for the radioactive waste would, however, not be available for at least another 15 to 20 years.

Degradation of stored waste under an extended storage environment is of great concern. The waste at the end of its storage duration must retain sufficient integrity to permit its final emplacement in a repository. An assurance that waste forms/packages can survive the rigours of handling and transportation to the disposal facility would be crucial to avoid widespread dispersion of contamination arising from their unanticipated failure. In addition to ensuring the physical integrity of waste forms/packages, acceptance criteria of the disposal facility will also place a limit on their level of radioactivity. Hence, there is a need for a quality assurance (QA) and a quality control (QC) program in support of our future low level waste disposal. The extent to which such a program is in place and operating will determine the need for any future reconditioning and repackaging of waste prior to disposal.

Considerable effort is being directed worldwide to the development of QA/QC procedures to ensure that low and intermediate level radioactive waste forms/packages meet production specifications and comply with waste acceptance requirements of the disposal facility. The work involves characterisation, determination of radionuclide

inventory, measurement of package performance and assessment of waste form/package quality following storage. Both destructive and non-destructive techniques are being researched with emphasis on the latter to avoid the need for additional waste conditioning or repackaging and the associated man-rem exposure.

Established waste acceptance specifications for SFR, the Swedish repository at Forsmark, the French Centre de la Manche, and provisional specifications for the proposed Konrad disposal facility in Germany and the Mol site in Belgium require QA/QC data in the areas discussed above. Although no disposal facilities have been identified in the UK, Nirex is preparing QA specifications and has established an independent Radioactive Waste Quality Laboratory at Winfrith. Similar requirements are also being developed in many other countries including the USA where the disposal of radioactive waste at a shallow land burial site is governed by the provisions of 10 CFR Part 61/2/.

In Canada, presently, the only guideline for disposal is concerned with the additional risk of causing a cancer/3/; the implementation of disposal is not regulated in detail as in the US. It is realistic to expect that the regulatory climate in Canada in the future when Ontario Hydro begins disposing its waste would be much more stringent than it is today. In keeping with the present guideline, AECL's approach/4/ for their IRUS (intrusion resistant underground structure) disposal facility involves 1) a determination of the inventory limits for the disposal facility based on performance assessment of the waste, 2) setting inventory limits on individual packages, and 3) emplacing wastes according to these limits and adjusting the total emplacement based on a running total of the activity.

2.0 SCOPE

A comprehensive research program addressing issues related to QA/QC of our low and intermediate level waste is developed. Specifically, non-destructive assay (NDA) of a waste form/package to determine its radioisotope inventory and non-destructive examination (NDE) to determine its integrity, presence of free liquid, extent of container corrosion, etc. are addressed. Existing capabilities are assessed and areas requiring research are identified. Priorities are assessed in the light of current and future waste management practices.

Program development was guided by the waste form requirements of 10 CFR Part 61. This was due to familiarity with its provisions and the belief that in substance these requirements are similar to those stipulated elsewhere.

3.0 WASTE MANAGEMENT AT ONTARIO HYDRO

Solid radioactive waste is segregated into three categories, namely, incinerable, compactable and non-processable waste. Incinerable waste gives rise to radioactive incinerator ash (volume reduction of 66) while the compactable waste is compacted into bales (volume reduction 4:1). Only solids are placed into storage; liquids are first immobilized using cement, polyester resin or a suitable absorbent.

Table 1 summarizes the classification of routine and some non-routine waste streams under the Ontario Hydro system and also according to NRC 10 CFR 61 regulation/2/.

Type 1 waste with a contact dose of less than 200 mr/h constitutes 95% of the solid low level waste. Type 2 wastes have dose rates between 200 mr/h and 15 R/h while those with fields greater than 15 R/h are called Type 3.

TABLE 1

CLASSIFICATION BY WASTE STREAM/1/

	Waste Classification	
Waste Stream	Ontario-Hydro	10CFR61
Processed		
Compacted	1,2 (a)	A,B (a)
Incinerator Ash	1	A
LSFCR(b)	1	A
	Non-processable	
Routine Non-pro. including filters	1,2,3	A,B
General LSFCR	1	A,B
LSFCR Pressure Tubes	3	C
Moderator Resins	3	>C
Heat Transport Resins	2	B (c)
Can-Decon Resins	2	A,B
	Miscellaneous Liquids	
Waste oil	1,2 (a)	A,B
Freon Dry Cleaning Sludge	1	A
Tritiated Liquids	3	A,B

a) Tritium concentration determines classification.
b) LSFCR, Large Scale Fuel Channel Replacement
c) CAN-DECON resin would be Class B if C-14 >0.8 Ci/m3; otherwise it is Class A.

The volume of the various types of solid wastes generated annually are shown in Table 2. Non-processable waste, not surprisingly, is the dominant contributor to the overall volume of solid waste.

TABLE 2

ESTIMATED ANNUAL PRODUCTION OF RADIOACTIVE SOLID WASTES AT ONTARIO HYDRO /1/

Solid Waste	Annual Generation (m^3)
Compacted Waste	180
Incinerator Ash	70
Non Processable	2025
General LLW	(1500)
General ILW	(75)
Resins	(180)
Filters	(20)
TOTAL	2275

The inventory and annual liquid waste arisings are given in Table 3. Note that while oils constitute most of the current inventory of liquid wastes, steam generator cleaning solvents are expected to make up the bulk of the annual generation in the future.

New Developments

In recognition of the considerable potential for waste reduction, Ontario Hydro has instituted a number of waste minimization strategies at the nuclear stations/5/. Approval is also being sought to direct de minimus waste from Pickering and Darlington to a public landfill site (similar waste from BNGS A & B is already being landfilled at BNPDS). New capital acquisitions, namely, a super-compactor and a replacement for the current incinerator are expected within the next few years. Waste minimization may lead to altered characteristics of the compactible and incinerable waste due possibily to a higher specific activity of the waste. Ash derived as a result and also due to possibly more efficient pyrolysis in a new incinerator would likely have different characteristics than that being generated presently. Super-compaction will replace the current baling operations and cause the disappearance of the routine non-processable waste stream. It is probable that existing baled and non-processable waste will eventually be re-processed using the super-compactor.

TABLE 3

INVENTORY AND ESTIMATED ANNUAL PRODUCTION OF RADIOACTIVE LIQUID WASTES AT ONTARIO HYDRO /1/

Liquid Waste	Inventory (m^3)	Annual Generation (m^3)
Oils	610	110
Miscellaneous Liquids	54	11
Freon sludge	0	10
Leak repair waste	13	5
Scintillants	0	3
Compactor effluent	0.2	6-20
HX cleaning solvent	2	60
SG cleaning solvent	0	4000
TOTAL	679	4220

4.0 NON-DESTRUCTIVE ASSAY OF LOW LEVEL WASTE

4.1 *Regulatory Requirements*

As discussed earlier, waste is classified into three types according to 10 CFR Part 61, namely, Class A, B, and C in a generally ascending order with regard to the degree of hazard. Classification is based on two considerations: 1) the concentration of long-lived radionuclides whose potential hazard persists long after the waste form has been disposed of - the radionuclides in this category are C-14, Ni-59, Nb-94, Tc-99, I-129, alpha emitting transuranics with halflives greater than 5y, Pu-241 and Cm-242 and 2) concentration of shorter-lived radionuclides for which institutional controls, waste form requirements and disposal methods are effective - this category includes H-3, Co-60, Ni-63, Sr-90, Cs-137 and all nuclides with halflives less than 5y. Classification requirements under the regulation demand assurance that radioisotope concentrations be known *within certain limits*.

Concentrations of radionuclides may be determined indirectly such as by material accountability or using scaling factors to infer the concentration of one radionuclide from another that is easily measured. Measurements may be averaged over the volume or weight of the waste.

Tritium, C-14, Fe-55, Ni-59, Ni-63 and Tc-99 are beta emitters and as such are not measurable non-destructively in a sealed waste package. Niobium-94 and I-129 are measurable using in-situ procedures only in the absence of other photon emitting radiosotopes/6/. Consequently, the only non-destructively measurable radionuclides of interest are Co-60, Sr-90 (see below), Cs-134, Cs-137 and transuranics and thus concentrations of other isotopes will have to be determined indirectly relative to these.

Cobalt-60, Cs-134 and Cs-137 are gamma emitters and are readily measured using a gamma detector. On the other hand, Sr-9O is a beta emitter. However, the high energy beta particles emit Bremsstrahlung radiation during deceleration in the matrix material which can be detected using a gammma detector by stripping out the gamma contributions of other isotopes in the spectrum/6/. Transuranics decay by alpha emission accompanied by x-rays but neither can be measured non-destructively; in fact, the only radiation detectable are neutrons emitted from spontaneous fission or from (alpha, neutron) interactions in light isotopes present in the matrix material/6-8/.

4.2 *Present Status of Waste NDA Within Ontario Hydro*

NDA is presently not an integral component of low level waste characterization at Ontario Hydro. Segregation and classification of waste, as stated earlier, is performed by the type of waste and its contact radiation field. An exception to this is the use of waste bag and large object monitors at BNGS to segregate very low activity waste (below regulatory concern) from other active waste. Information on the radionuclide content of stored waste has arisen largely from waste characterization studies performed at Research Division. Typically, these studies attempt to quantify gamma emitters present in the waste by in-situ gamma spectrometry, destructively assay for beta emitters C-14 and H-3 using scintillation counting and assess alpha activity by inference based on the gamma peak counts of Am-241 (a weak gamma emitter)/1/.

Radioassay results for the various waste streams are summarised in Table 4. Note, that alpha activity in general is relatively low compared to beta/gamma activity. Also note the unavailability of any data for routine non-processable waste.

4.3 *Waste NDA - What Needs to be Done*

Compacted Waste

The individual polyethylene bags constituting baled waste have been characterised/10/. Also preliminary attempts using in-situ gamma spectrometry to assay baled waste have been made/11/. While waste characteristics have historically remained unchanged, this may alter due to waste minimization initiatives and increased incidence of reactor maintenance. A renewed attempt to characterize this type of waste would thus be required.

Possible scenarios for disposal of compacted waste are: 1) repackage and dispose, 2) super-compact and dispose, 3) dispose at a landfill site following an extended period of decay, and 4) incinerate and dispose ash - unlike the present facility, the new incinerator may allow incineration of compacted waste. In-situ methods to quantify waste activity would be required in all cases; in the last option, the radionuclide inventory of the ash could be determined as discussed next.

Gamma spectrometry of a compacted (baled or super-compacted) waste package should be relatively straightforward considering the low density of the material. The feasibility of ascertaining Sr-90 content by spectra stripping would have to be demonstrated. Both alpha and beta activities may be inferred from the total gamma

activity as has been demonstrated for incinerator ash/12,13/. In support of the above, coring procedures may be required to allow sampling for H-3 and C-14 determination.

TABLE 4

AVERAGE CONCENTRATION (mCi/m^3)
OF SELECTED RADIONUCLIDES IN SOLID WASTE/1,9/

WASTE STREAM	H-3	C-14	Co-60	Sr-90	Cs-137	ALPHA
Compacted	9,900	0.004	2.7	na	1.1	(a)
Incinerable (Routine)	2000	0.002	0.2	na	0.03	(a)
Incinerable (LSFCR)	100	5	0.3	0.03	0.02	0.001
Incinerator Bottom Ash	0.7	1.4	21.6	1.6	8.6	<0.07
Non-process. (Routine)	na	na	na	na	na	na
Non-process. (LSFCR)	0	500	200	(a)	3.0	1.0
IX Resin (Moderator)	(b)	$127x10^3$	$121x10^3$	1.0	450	na
IX Resin (PHT)	(b)	2,200	613	97	$34x10^3$	na
IX Resin CANDECON	(b)	na	3,633	na	32	na

na - not yet available.
(a) - not measured, but less than for LSFCR incinerable waste.
(b) - neglibible

Incinerator Ash

The ash is classified as Type A waste due to its low specific activity although due to its hazardous metal constituents it should more appropriately be considered as a mixed radioactive waste/9/. Waste minimization initiatives may result in an increased specific activity of the ash and possibly alter its radioactive classification. Ash characteristics should therefore be re-examined in the future.

Presently, ash is stored in galvanized rectangular containers (bottom ash) and carbon steel drums (baghouse ash) inside the low level storage buildings. For disposal or declassification (ie, de-minimis waste), activity of the ash would have to be ascertained. In-situ measurements would be simpler to perform under present levels of activity rather than following an extended period of decay.

Determination of the level of gamma emitters may involve the use of a segmented gamma scanner. To determine the overall activity, an approach similar to that employed at Chalk River/12,13/ could be adopted. As previously mentioned, this involves the use of correlations between gamma and beta or alpha activity. If required, correlations can be developed to give scaling factors for each specific beta or alpha emitting radionuclides.

Routine Non-Processable Waste

Routine non-processable waste contains steel components in addition to lower density material. Its composition may vary significantly not only between containers but often within the same container. The unavailability of data in Table 4 for this waste stream in part reflects the difficulty in assaying the heterogeneous material. Crude attempts have been made to quantify its activity by gamma spectrometry based on a point source efficiency treatment/14/. Clearly, more sophisticated procedures are warranted since self-absorbtion effects cannot be satisfactorily accounted for in this manner. Even so it is important to recognize that their accuracy does not necessarily have to compete with that of destructive analysis.

The impact of super-compacting on the feasibility of determining the activity of this type of waste must be considered. Super-compaction will increase the density, homogeneity and volumetric activity of the waste. While increased homogeneity and activity would facilitate measurement, the increased density could prevent activity measurement of all but the most intense gamma emitting radionuclides.

Significant effort will be required to develop methods for interpreting container activity. Pertinent literature, however, appears to be available. For instance, one procedure/15/ involves a comparison of the relative intensity of different photopeaks from the same radioisotope and matching them to those measured in standards of known density. Another approach/16/ may be based on a joint consideration of photopeak counts and Compton scatter.

Correlation of beta and alpha activity with gamma activity may prove to be more elusive for this waste category unless it is attempted for containers with similar waste characteristics.

Non-routine Non-Processable Waste

Type 1 LSFCR (reactor retubings) waste consists of stainless and carbon steel reactor face components and specialized tools. While the waste is generated infrequently, the quantities involved are very significant. Other re-hab projects and heat exchanger replacements also generate Type 1 non-processable waste.

Replaced LSFCR pressure tubes and end-fittings are stored in dry storage modules (DSM) and constitute a Type 3 waste; no attempt is made to assay them prior to storage. In addition to corrosion and activation products, the components are likely

to have significant levels of alpha and beta (C-14) activity. It is conceivable that a gamma detector with adequate shielding provisions could be used to monitor the components during their transfer into their DSMs; the cumulative count generated could then be used to determine gamma activity/16/. Destructive analysis would be required to correlate alpha and beta activities with gamma activity. An alternative to direct measurement would be to rely on characterization results obtained from pressure tube examinations at Chalk River.

Besides the above, there exists in storage two other waste components, namely, obsolete stainless steel PNGS fuel storage baskets and PNGS moderator and shutdown cooling heat exchangers which are characteristically large in size and have complex geometries. The basket surfaces are contaminated with Co-60, Cs-137 and alpha activity/17/ while the activity of the heat exchangers is principally due to Co-60.

Assay of the Type 1 LSFCR waste could use the same methodology as that developed for the general class of non-processable waste. For the other non-routine waste, where possible or adequate, the preferred technique may be to rely on results of destructive characterization. A clear need to develop in-situ procedures for this waste stream does not appear to exist presently.

Ion Exchange Resins

Carbon-14, Co-60 and Cs-l37 are the principal radionuclides on moderator and heat transport resins while CAN-DECON resins are principally loaded with Co-6O. The de-watered resins are stored in carbon steel liners within the quadricells and in inground containers (IC 12) at BNPDS. Due to insufficient characterization, the inventory of radionuclides on various resins in storage is poorly known.

Alternatives for measuring the inventory of radionuclides on resins include 1) estimation from operational feed composition data, 2) from destructive analysis of resin samples drawn during slurry transfer operations (it is worth noting that in US plants, resins are routinely sampled for waste classification prior to solidification)/18/, 3) direct assay of slurry transfer lines, and 4) direct assay of resins in storage liners. Reliance on Option 1 may not be prudent and Option 2 is obviously not applicable to resins in storage. Development of Options 3 and 4 in conjunction with Option 2 to furnish the scaling factors for beta and alpha emitters would enable a complete assessment of resin inventory.

Direct assay of slurry transfer lines has been attempted in Ontario Hydro; the procedure, however, needs to be refined. Direct assay of resins in storage has so far not been attempted; it may possibly be accomplished by lowering a collimated detector within the effluent sampling line that runs along the height of the IC 12.

Immobilized Liquid Waste

Liquids are required to be immobilized prior to storage at the Bruce waste management site. Presently, tritium contaminated hydraulic oil constitutes a major liquid waste stream. Significant additional waste volumes will arise from planned chemical cleaning of Bruce steam generators and biological shield repairs at Pickering.

Determination of activity in immobilized liquid waste drums can be based on assay of the liquid prior to immobilization. In the absence of this information, in-situ gamma spectrometry and alpha and beta activity determination by destructive analysis would be required.

Considering the ease of assaying liquid samples prior to immobilization and the low volumes of previously solidified liquid wastes, there appears little justification for developing an in-situ assaying procedure for this class of waste.

One final general comment regarding alpha activity measurement: its measurement by inference with gamma activity has been repeatedly suggested in the preceding discussions. However, alpha activity, unlike beta activity, is measurable non-destructively using either passive or active neutron interrogation techniques/8/. Passive techniques are inherently simpler, less expensive and more sensitive to a wider spectrum of transuranics than active techniques and hence more likely to be suitable for LLW assay. A system may be required if suitable correlations between alpha and gamma activities can not be established.

5.0 NON-DESTRUCTIVE EXAMINATION OF LLW

5.1 *Regulatory Requirements*

According to 10 CFR Part 61/2/ all classes (A, B AND C) of waste must meet minimum requirements concerning: (1) a prohibition against the use of cardboard or fiberboard boxes, (2) treatment, packaging and maximum quantities of liquid wastes,(3) restictions concerning disposal of explosive or detonatable wastes, (4) restrictions against wastes containing or capable of generating quantities of toxic gases, vapors, or fumes, (5) a prohibition against pyrophoric wastes, etc.

In addition to the minimum requirements, Class B and C wastes must meet stability criteria. Stability is intended to ensure that the waste does not structurally degrade and affect overall stability of the site through slumping, collapse or other failure of the disposal unit and thereby lead to water infiltration/2/. The regulation further limits the amount of free standing or corrosive liquid to 1 % by volume of the waste when it is in a disposal container or 0.5 % by volume of the waste when processed to a stable form and stipulates that void spaces within the waste and between the waste and its package must be reduced to the extent possible.

Note that the minimum and stability requirements stated should also apply to wastes under extended storage. Otherwise, reconditioning would be required in the future prior to disposal.

Based on the above, inspection of waste packages would be required to determine:

1. physical contents - for identification of waste contents, detection of liquid in baled waste, etc. Applicable techniques include x-ray and neutron radiography and computer aided tomography;

2. presence of voids - large voids in immobilized waste may necessitate reconditioning of the waste. Applicable techniques include x-ray and neutron radiography and computer aided tomography;

3. leak-tightness of container to guarantee against water entry;

4. gas pressurization - gas generation may cause rupture of container. Passive venting provisions may alleviate this concern;

5. container corrosion - integrity of the container must be assured for purposes of handling, transportation and to prevent entry of water. Applicable techniques include ultrasonics and neutron radiography;

6. presence of liquid - liquid in excess of regulatory limits may necessitate reconditioning of the waste; corrosion rate of container material may also be accelerated. Pertinent techniques include neutron radiography, thermal imaging, impact echo and in the case of liquid waste being immobilized monitoring the torque or temperature during the curing stage.

Good process control measures may ensure that waste packages being admitted to a repository conform to regulatory requirements. Despite this it is desirable to have an inspection system which can directly verify compliance. In the context of a waste repository, it is doubtful that a production throughput can be attained based on opening and inspecting containers without the construction of a large and expensive environmentally controlled facility. Hence the need for NDE techniques. It is recognized, however, that occasional destructive analysis will still be required.

5.2 *Waste NDE - What Needs to be Done*

Wastes to date have primarily been characterized as to their chemical and radiochemical content; no significant attempt has yet been made to determine the physical integrity of the various types of stored waste. It is known, however, that baled and super-compacted waste and IX resin liners contain free liquid which could have adverse consequences on their integrity and also cause gas generation. Hence, an NDE capability to detect the presence of free liquid and generation of gas within such waste packages would be desirable. Also, the ocurrence of a recent fire due to the presence of an aerosol can in waste being baled indicates the need for NDE techniques to screen waste prior to being processed.

Table 5 lists some perceived NDE requirements for the production and disposal/storage of various types of waste packages. Assessment of corrosion and leak-tightness are considered to be general requirements for all types of packaged wastes. Hence, these are not listed in the Table. Items 2, 4, 6 and 8 refer to wastes expected routinely in the future - items 2 and 6 represent baled and non-processable waste which will likely be super-compacted.

6.0 CLOSING REMARKS AND RECOMMENDATIONS

The preceding sections have attempted to examine the issues pertinent to the disposal or extended storage of various reactor wastes. Disposal will require information on the inventory of radioisotopes within waste packages as well as an assurance of the integrity of individual waste packages. Results from the ongoing reactor waste characterization studies provide a sound basis for developing non-destructive assaying techniques in support of disposal. The characterization effort needs to be maintained as waste characteristics change due to altered waste management practices.

TABLE 5

PROBABLE NDE REQUIREMENTS FOR VARIOUS TYPES OF WASTES

Type of Waste	Physical Content	Voids	Free Liquid	Gas Generation
Baled Waste	x		x	x
Super-compacted 'Baled' Waste	x		x	x
Ash Container			x	
Immobilized Ash		x		x
Non-processable Waste Containers	x			
Super-compacted 'Non-processable' Waste	x		x	x
IX Resins			x	x
Immobilized IX Resin and Liquid		x	x	x

Based on the earlier considerations, the following NDA related work is required:

1. Develop correlations between the activities of gamma, beta and alpha emitters - while the work involves destructive sample analysis, the correlations would enable the activity of beta and alpha emitters within waste packages to be quantified based on in-situ measurement of their gamma activity.

2. Investigate techniques for in-situ gamma spectrometry

The work should focus on the major routine waste streams, namely, compactible, incinerator ash and non-processable waste (including IX resins) and consider waste packages arising from both current and future processing methods including immobilization where appropriate. With respect to Item 2 above, a comprehensive literature review and assessment of available technologies (a number of new drum assay systems have recently been described and are also commercially available/19,20/) should be a logical first step.

Unlike the availability of waste radionuclide characterization data, not enough is known about the state of the stored waste to allow a clear indication of NDE research priorities. An exception to this is the known presence of liquids within some types of wastes. A related concern would be the presence of liquids arising from improper immobilization of liquid wastes.

A partial list of NDE related research topics worthy of consideration includes:

1. Detection of free liquid by thermal imaging and neutron radiography,
2. Methods for cure monitoring,
3. Radiography of large size waste form,
4. Neutron radiography and back-scatter techniques to assess their relative strengths compared to x-ray radiography,
5. Container integrity issues - wall thickness, corrosion buildup, presence of cracks/defects using ultrasonics, neutron radiography etc. and
6. Monitor developments in CAT, evaluate its ability to simultaneously perform both NDA and NDE.

Item 1 merits a high priority relative to other items in the above listing while Item 2 is contingent upon the undertaking of large scale liquid immobilizations. In general, an assessment of the state of stored waste must be carried out first to better assign research priorities.

7.0 ACKNOWLEDGEMENTS

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